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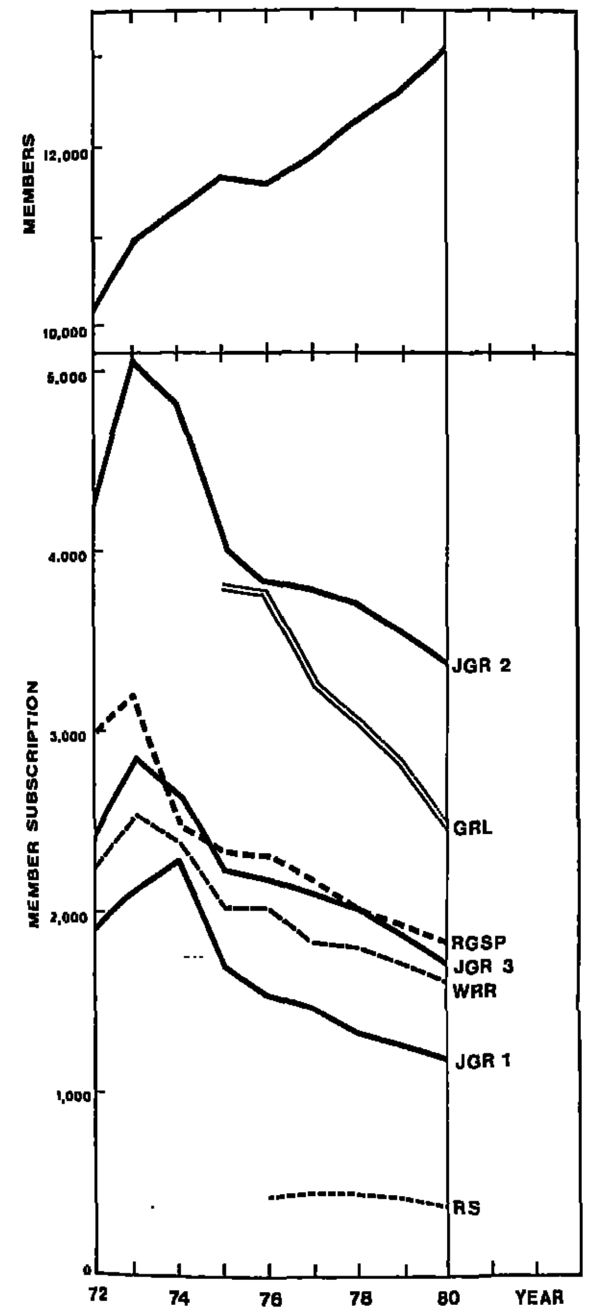
Editorial

Member Subscriptions

The Publications Committee solicits comments and advice from the membership about the decline in member subscriptions to AGU journals. The phenomenon is illustrated below. During the period of this decline AGU membership has increased by several thousand, and there have also been marked increases in participation in annual meetings and in the numbers of papers submitted for publication. We therefore conclude that declining circulation is not due to a declining population of geophysicists or to decreasing research activity. What are the causes, and how can the trend be reversed?



An obvious hypothesis is that the decline results from increasing subscription rates. If this is true, what is the appropriate response? Prices to members reflect the costs of fulfilling member subscriptions and depend on the sizes of the journals. Lower prices can be charged for smaller journals. Should JGR be further subdivided? Should AGU establish new journals, more narrowly focused, and therefore potentially smaller, than those we already have? If so, to what extent should the subject matter of new journals be restricted to avoid competition with existing AGU journals?

Please let us hear from you on this or any other matter concerning AGU journals and books.

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A Preliminary Systems Analysis of Impacts of Proposed Soviet River Diversions on Arctic Sea Ice

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Introduction

Vast river diversion projects could be under construction by the end of the century in the USSR and ultimately reach several hundred cubic kilometers annually. The most seriously considered would take water from major Arctic draining rivers (Ob, Yenisey, Pechora, and Northern Dvina) and transfer it to western and southern regions of need (Figures 1 and 2). These grandiose undertakings would result in significant hydrologic, climatic, cryogenic, biotic, pedologic, and geomorphic changes. Most of these would be of local or regional scale and confined to the Soviet Union [*Micklin*, 1979]. However, some macroscale alterations with international implications are possible. Of these, modifications in the sea ice cover of the Arctic Ocean that are induced by diminution of freshwater discharge are the most serious. Sea ice plays a key role in the Arctic mass and energy budgets, diminishing water vapor, heat, and momentum exchange between the ocean and atmosphere and affecting pressure and circulation patterns over the entire Northern Hemisphere [*Budyko*, 1974; *Lamb*, 1978; *Flohn*, 1979]. Significant alterations in its extent, thickness, concentration, duration, and distribution would have important consequences not only for Arctic but Northern Hemisphere climate.

This study is a preliminary attempt to evaluate the potential effects of proposed river diversion projects on Arctic sea ice. It employs a systems approach, primarily utilizing Soviet studies and data on the Arctic, to qualitatively delineate the potential impacts of diversions and to indicate which of these may be most crucial. This is a logical antecedent to a rigorous quantitative analysis of this problem.

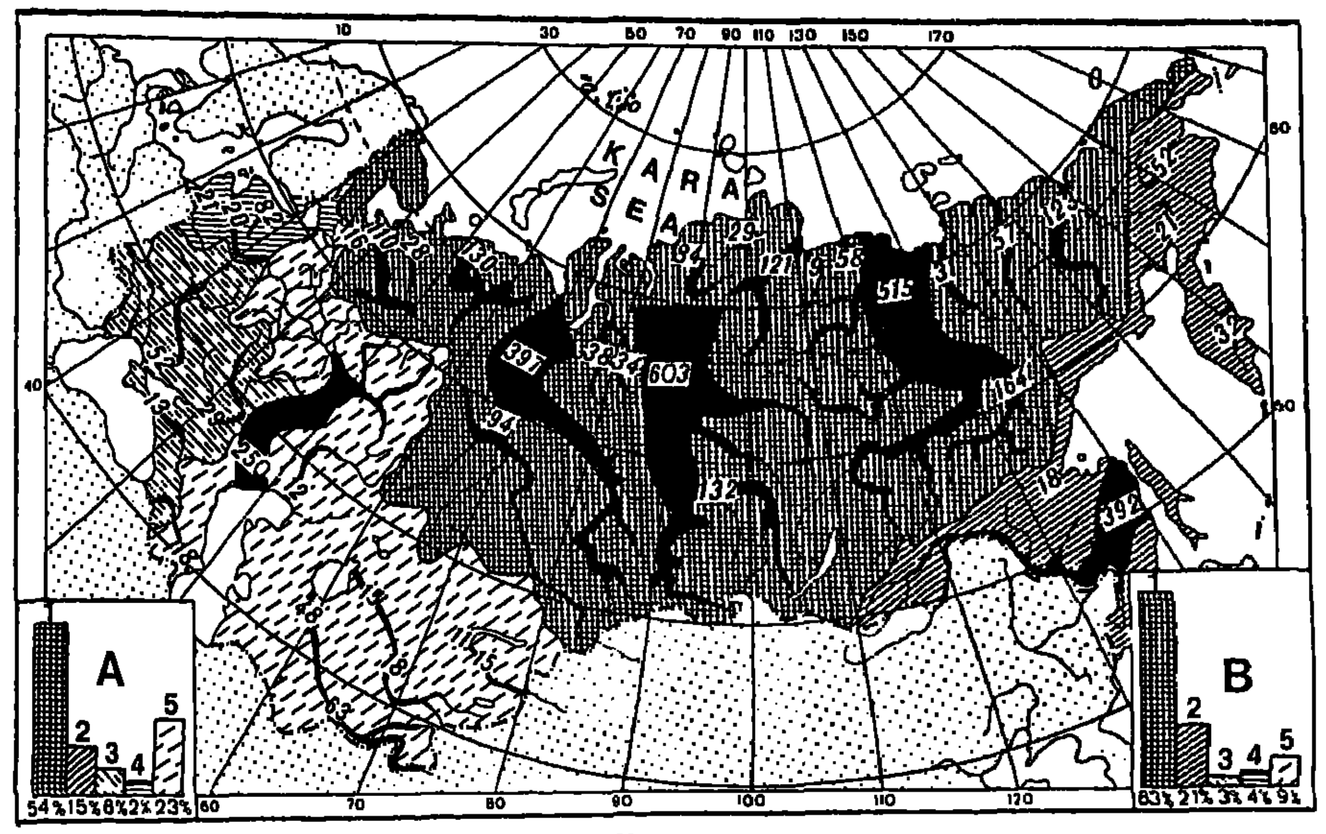

Fig. 1. Mean flow USSR rivers (km³/year). (A) Percentage of USSR's territory with river discharge into specified sea and ocean basins. (B) Percentage of USSR's average annual river discharge accounted for by rivers flowing into specified sea and ocean basins. Numbers in boxes A and B indicate: 1—Arctic Ocean Basin; 2—Pacific Ocean Basin; 3—Black and Azov sea basins; 4—Baltic Sea Basin; 5—Caspian and Aral sea basins. (Source: *Nikolskiy et al.* [1975].)

Kara Sea System

Even though the contemplated diversions are very large in absolute terms and dwarf existing water transfer projects, they are negligible by comparison with the Arctic water budget. This is a major impediment to analysis. Thus, first-stage removal of around 60 km^3 represents only 1.7% of estimated average annual freshwater runoff (3508 km^3) to the Arctic Basin and its marginal seas (excludes Hudson Bay and Strait, Foxe Basin, Baffin Bay, and the Greenland and Norwegian seas) and 0.02% of saltwater influx [*Ivanov*, 1976b; *Aagaard and Greisman*, 1975]. Even upper-limit transfers of around 300 km^3 annually, possible some time in the next century, equal 8.5% of freshwater and slightly more than 0.1% of saltwater inflow, respectively. Consequently, determination of possible Arcticwide consequences of water transfers on sea ice is very difficult because of the masking effect of background noise from substantial natural interyearly variation. Hence, analysis has been restricted to possible impacts on the ice cover of the Kara Sea. This water body's drainage basin contains the Ob and Yenisey rivers, from which the largest transfers are proposed. This sea has an area of 885,000 km^2, around 10% of the area of the Arctic Basin and its marginal seas. The average annual continental runoff of 1350 km^3, composed of river flow and glacier melt, is especially important in its water budget, equivalent to a 1.52-m layer over its surface. This compares to an average thickness of 0.4 m of runoff over the entire Arctic Basin and its marginal seas. It is normally entirely covered with ice in winter but about half ice-free during summer. The sea is a major source of ice formation and export to the Arctic Basin in winter [*Zakharov*, 1976]. The general Arctic cooling trend of 1940–1970 was most strongly manifested here and led to an estimated 23% increase in ice cover. Soviet researchers contend the Kara Sea, along with northern Greenland, acts as a center of climatic fluctuation for the Arctic [*Zakharov*, 1976]. It is reasonable to expect that the effects of diversions on sea ice would be most intense and appear first here. Furthermore, substantial changes in Kara Sea ice could trigger alterations in the sea ice regime over much larger portions of the Arctic.

Figures 3 and 4 and Tables 1, 2, and 3 present some basic data on the Kara Sea which are pertinent to the impact of river diversions on sea ice. This information has been compiled or calculated from a variety of Soviet sources of different ages and reliability. Hence, it is more indicative than exact and may be subject to considerable error. This illustrates another dimension of the problem of evaluating potential impacts of river diversions: a glaring insufficiency of reliable baseline environmental data. For example, calculation of the upward heat flux from deep Atlantic water, a critical element in the Kara Sea's thermal budget, is based on data in several Soviet studies dating back to the early 1960s [*Timofeyev*, 1961, 1962; *Panov and Shpaykher*, 1963]. These were based on limited field observations, and they arrived at significantly different results.

In spite of their limitations, the tables and figures suggest that river inflow from the Ob and Yenisey is of fundamental importance in the freshwater balance of the Kara Sea, contributing 67% of the total gain (Table 1) and significantly influencing summer salinity and temperature conditions over nearly 50% of the sea's surface (Figures 3 and 4). They also indicate that the upward flux from deep Atlantic water in winter, thought to be influenced by continental runoff, is of major importance to the sea's heat budget and has a critical impact on winter ice conditions in the northern part of the sea (Table 3, Fig. 4). The great change of ice conditions between summer and winter and the role of river flow in this variability is suggested by comparison of Figures 3 and 4 and Table 2.

Figure 5 is an attempt to diagrammatically represent the main ocean-sea ice linkages of the Kara Sea system that are affected by river diversions and to indicate the character of the connections. (This model is based on a more complex

AGU Job Center at Spring Meeting

AGU will initiate a Job Center for the benefit of registrants and prospective employers at the Spring Meeting in Baltimore. The purpose of this center is to facilitate scheduling of interviews between registrants seeking employment and employers seeking qualified personnel to fill their job vacancies. Job descriptions of open positions will be posted on bulletin boards at the center. Employers planning to attend the meeting should bring job descriptions for posting to the registration desk and fill out a form indicating when someone will be available for interviewing.

Job candidates should bring resumes with them to the meeting. Resumes will be held confidentially but will be open for review by registered prospective employers. Job candidates can review the posted positions and sign up at the Job Center desk.

Interviewing will take place from 9 A.M. to 4 P.M. Tuesday through Thursday in Exhibit Hall A. Applications and job descriptions can be left at the Job Center in the Baltimore Convention Center from 8 to 4 from Monday on.

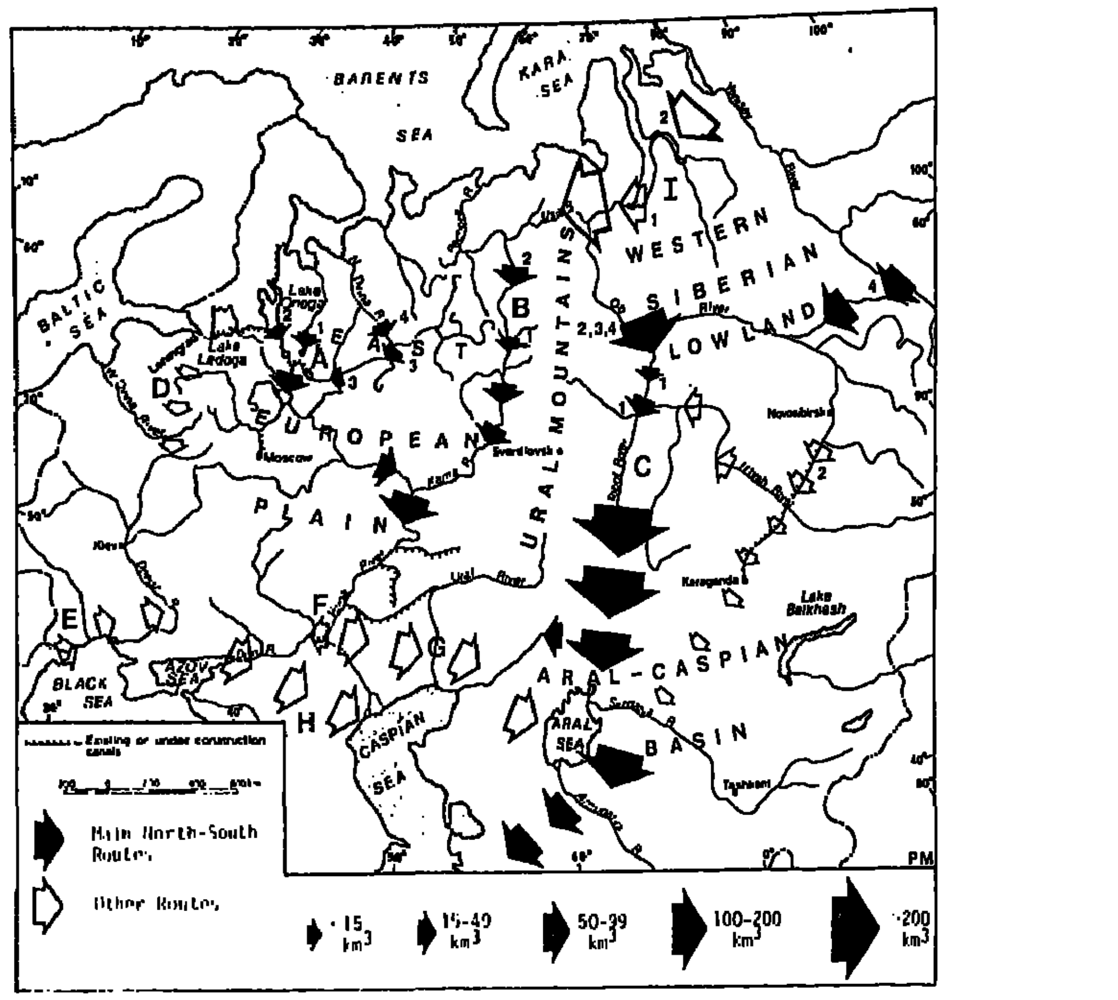

Fig. 2. USSR water diversion proposals. (A) Western European variant (35 km³): stages—1(4); 2(11); 3(22); 4(35). (B) Eastern European variant (31 km³): stages—1(13); 2(31). (C) Northwest-Dnepr (10 km³). (D) Danube-Dnepr (24–30 km³). (E) Volga-Don (25 km³) (F) Lower Volga-Central Asia (63 km³). (G) Siberian (more than 200 km³): stages—1(25); 2(60); 3(100); 4(more than 200). (H) Azov Sea-Black Sea (85 km³). (Source: P. Micklin)

scheme formulated by the author, consisting of 75 state variables and 130 linkages, which attempts to represent the complete ice-ocean-atmosphere system of the Kara Sea.) Besides indicating the key state variables of the system that could be influenced by a reduction of freshwater inflow, the direction and qualitative character of the linkages is shown. Thus, both the connection pattern and the sign (i.e., plus or minus) of the incremental change in the dependent *(y)* variable, caused by an incremental change in the independent *(x)* variable, is shown. Although a great simplification of reality, the model provides an appreciation of the complex effects river diversions could have on the ocean-ice system of the Kara Sea. Furthermore, it illustrates the difficulty of ascertaining the net result (more or less ice) of reducing freshwater inflow.

Diversion Impacts

Two scenarios of the consequences of river diversions are traced through the system. *Aagaard and Coachman* [1975] hypothesized an increase in surface-layer salinity, which would promote winter convection and upward heat flux from the relatively warm (0.08° C) layer of deep Atlantic water underlying the colder (−1.8° C) surface waters of the northern part of the Kara Sea and the southern portion of the European Arctic Basin. This, they predict, would lead to a reduced ice cover and a warmer Arctic. (The authors recognized, however, the possibility of negative feedback mechanisms, which could counteract these changes.) On the other hand, several Soviet researchers at the Arctic and Antarctic Institute in Leningrad take a different view [*Antonov*, 1963, 1970, 1976; *Ivanov and Nikiforov*, 1976]. They foresee a reduction of the upward heat flux from the deep Atlantic water. This would result from a lessening of the Atlantic water entering the Arctic Basin and the Kara Sea because of a diminution of the intensity of surface gradient currents out of the latter. In addition, they postulate a decrease in the export of ice from the Kara Sea along with delay of the spring ice breakup and melt in and adjacent to the Ob and Yenisey gulfs. The aggregate influence of these changes would be heavier ice conditions. The analyses of the Soviet and American investigators arrive at different conclusions because of their concentration on different parts of the total affected system. The complete system is so complicated that the net impact of diversions on sea ice would be difficult to determine without a sophisticated numerical model of its operation.

Nevertheless, the linkage model (Figure 5) provides a basis to qualitatively evaluate the main impacts of diversions on the Kara Sea ocean-sea ice system. First, the system is separated into its four basic components (Figure 6). Then, critical pathways analysis is employed to identify the key linkage pathways and feedback loops of each and to analyze these in terms of their effects on system stability, the character of the sea ice cover, and some key related variables. This approach not only allows estimation of overall impacts but, equally important, delineates the most sensitive linkage pathways and feedback loops that need further intensive investigation.

The analysis suggests that the overall impact of diversions may well be to increase the ice cover of the Kara Sea, since 10 linkage pathways or feedback loops tend to promote more ice, whereas only two tend to reduce it. Also, the system appears unstable since instability heavily outnumbers stability-promoting pathways or loops. Interestingly, effects of diversions on winter sea surface salinity and ice conditions in the northern Kara Sea will probably not be pronounced because of the dominance of negative (i.e., stability-promoting) feedback loops. On the other hand, the remaining three subsystems (IB, II, and III) could well cause significant changes since they are dominated by important instability loops or linkage pathways. It should be noted that the summer sea surface salinity component would tend to lead to less ice, whereas the surface export currents and summer ice melt and breakup pathways point toward more ice.

Several caveats about this analysis are in order. First, the 15 linkage paths and loops are assumed to be of equal importance; in fact, such equality is improbable. Second, linkages between the subsystems are not considered nor are many important atmospheric connections. Third, selection of the most important linkage pathways and feedback loops is subjective, although based upon a careful review of relevant information. In regard to the last, further analysis may show that linkages involving upward heat conduction through the winter ice cover (variables 6a and 6b of the winter sea surface salinity subsystem) are of critical importance. Recent work by *Maykut* [1978] shows this flux to be large over the ice up to about 0.4 m but insignificant for ice of more than a meter. Hence, whether to consider these linkages critical or not depends on careful analysis of the extent and duration of ice of different thicknesses in the Kara Sea during winter. By the same measure, the exogenous oscillating system in component II of Figure 6 may be of critical importance. Basin thermal and mass exchange between the Arctic Basin and the Atlantic [*Antonov*, 1968]. If so, its influence on the heat balance and ice regime of the Kara Sea would be significant.

Figure 7 delineates areas of the Kara Sea most likely to be perceptibly affected by river diversions. The map clearly illustrates the spatially variant impacts. Effects in and adjacent to the estuaries of the Ob and Yenisey and over shallow sea shelves would be different than over the deep water canyons underlain by a sensible heat source (K. Aagaard, personal communication, 1980). Consequently a

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Cover. Landsat image of the Ob River delta and southern part of Ob Gulf (August 11, 1973). Even initial diversion of 25 km³/yr from the Ob could have significant effects on the ice regime here. Remnant fast ice is visible along the shore.

Forum

Pluto revisited

A. J. Dessler and C. T. Russell (*Eos*, Forum, October 28, 1980) are behind the times. Pluto already disappeared into Never-Neverland and has returned again! Dessler and Russell committed several blunders in their analysis that were further obfuscated by their failure to adhere to such fundamental AGU standards as showing error bars and publishing references.

Nevertheless, I have unearthed an old, dusty issue of *Science*, wherein one finds that *Ash et al.* [1971] report a value for Pluto's mass that probably accounts for the third last data point in Dessler and Russell's graph. But Ash et al's value reflects their assumption that the density is 3 gm cm³. They actually measured a negative mass.

You see, unlike the open-minded Dessler and Russell, Ash et al. were so biased in favor of a positive mass for Pluto that they discarded their own determination that the mass of Pluto is −0.081 (±0.005) times the mass of Earth. Had Dessler and Russell included this definitive determination of Pluto's negative mass in their analysis (with or without error bars), they would have arrived at far different conclusions.

In particular they would have seen that Pluto's mass is actually increasing. Far from having to launch a PLOTO mission in the immediate future, we can proceed with the Halley intercept and VOIR missions secure in the knowledge that Pluto will still be exhibiting accretionary behavior well into the next century.

References

Ash, M. E., I. I. Shapiro, and W. B. Smith, The system of planetary masses, *Science, 174*, 551–556, 1971. (Readers should refer especially to pp. 554 and 555, as well as to footnote 37.)

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Planetary Science Institute
Tucson, Arizona

I am astounded that scientists of the calibre of Dessler and Russell are able to arrive at such ludicrous interpretations of the data on the mass of Pluto as they have reported in the Forum in *Eos* on October 28, 1980. Clearly, the most consistent interpretation of the decrease by 4 orders of magnitude in the ratio of the mass of Pluto to that of the earth is that the earth is getting heavier.

This hypothesis also explains many other phenomena, such as my increasing difficulty in getting around as well as I did 20 years ago. Furthermore, NIAHOALMLTFAPTSTETOTSADP (NASA is a heck of a lot more likely to fund a program that studies the earth than one that studies a distant planet).

In closing, let me plead with you to publish this comment since my publication list this year is very thin (C. Russell, public communication, 1980).

Forrest Mozer
Professor of Physics
University of California, Berkeley

The elegant formula of the Pluto mass derived by Dessler and Russell (*Eos, 61*(44), 690, 1980) reminds me of my conversation some years ago with my daughter, who was a physics senior at Rice. In explaining Buddhism incarnation, I introduced the imaginary time which changes the exponential function decaying with time (representing entropy or other quantity) into the circular function of time with the real and imaginary parts. I interpreted that both are existing, but only the real part is perceptible to human beings. She thought I became crazy. Well, how do you two gentlemen interpret your formula in terms of the realistic time which is complex, instead of the real time?

Takashi Ichiye
Professor, Texas A&M University

Russell freely admits to circular reasoning.—Ed.

In the light of President Reagan's attitude toward equal rights for women (not necessarily for the ERA!), perhaps NASA would fare better in its quest for comet funds if it were to accompany the proposal for the 'Halley Intercept Mission (Him)' by a Halley Exploration Report ( ).

James Hugh Nelson
Tucson, Arizona

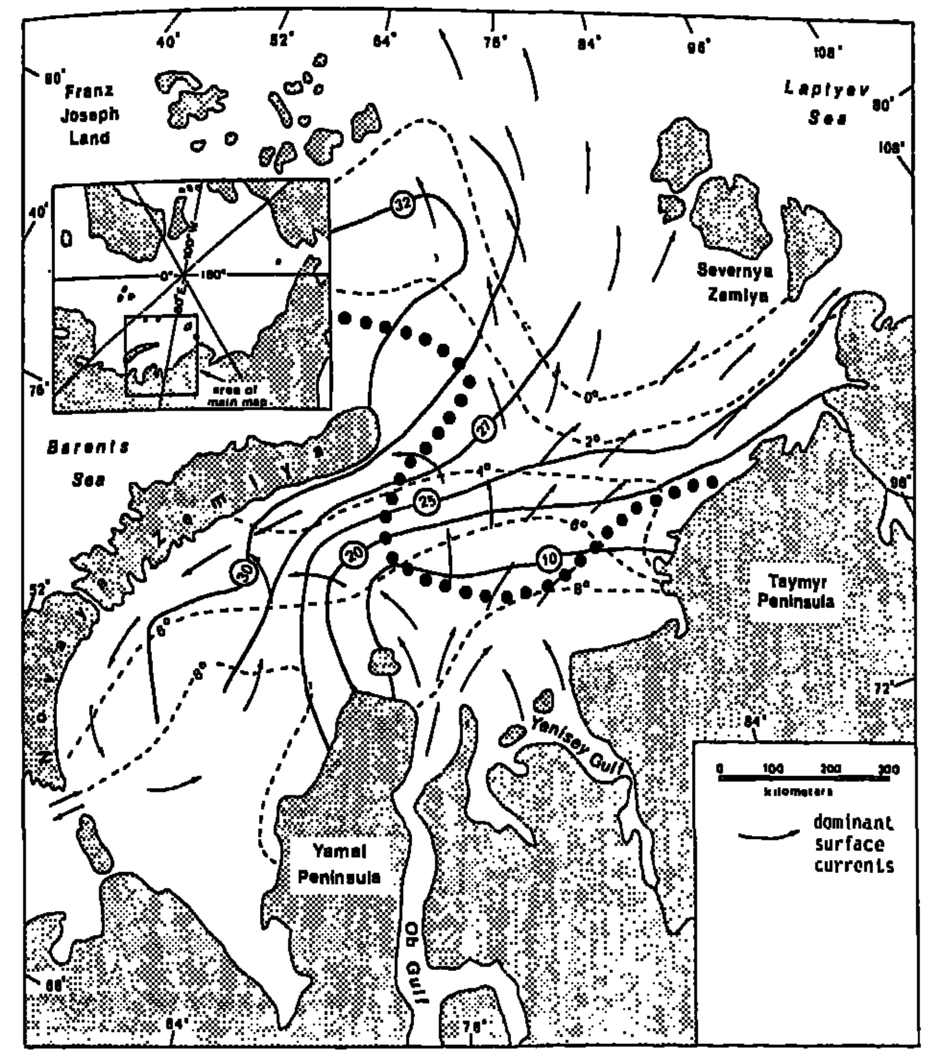

Fig. 3. Kara Sea: physical characteristics I. Bold dots—average minimum extent of sea ice (1/8 or greater concentration); dashes with degree numbers—average annual summer sea surface temperature (°C); solid lines with circled numbers—average annual summer surface salinity ‰). (Sources: *Institut geografii* [1970]; *American Geographical Society* [1975].)

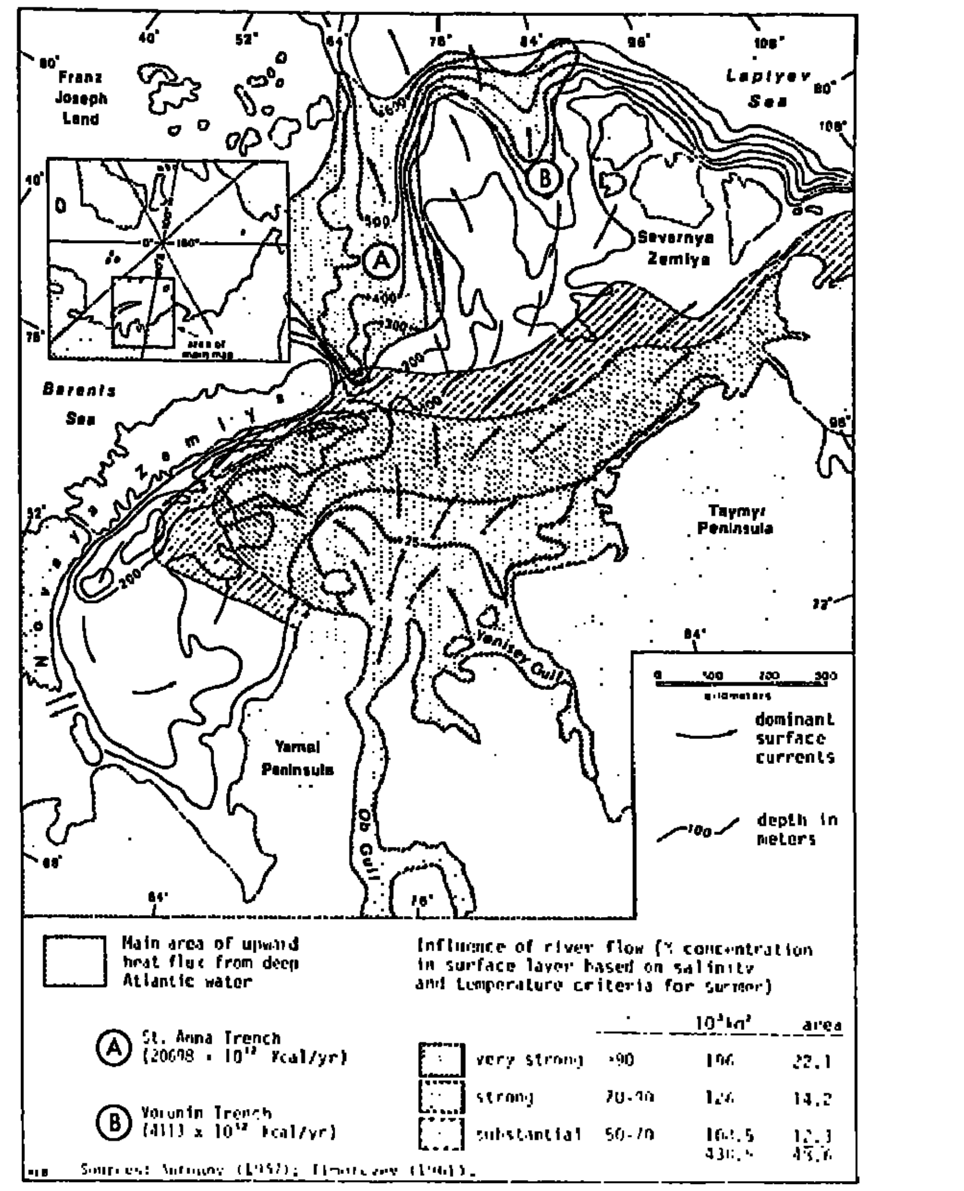

Fig. 4. Kara Sea: physical characteristics II. (Sources: *Antonov* [1957]; *Timofeyev* [1961].)

realistic simulation model of the entire system should be composed of coupled regional submodels that give appropriate weight to these distinct processes.

Table 4 contains first approximations of direct changes in some important parameters of the Kara Sea brought about by diversions. Initial stages of transfer (I and II) would cause small direct changes (not more than 5%) in freshwater, heat, ice, and salinity parameters characteristic of the sea as a whole. A logical inference is that diversion of up to 60 km³/yr is unlikely to extensively modify the Kara Sea ice cover. Indeed, this is the firm contention of the Soviet government [*Soviet Weekly*, 1979]. However, even seemingly minor direct disturbances merit caution. There are numerous variables and linkages that would be affected. Furthermore, the possibility exists that in such a complex natural system multiplier, synergistic, threshold, and nonlinear effects could translate small direct changes into major indirect alterations.

For example, the combined Ob-Yenisey discharge is less than 3% of the gain side of the sea's water budget. Nevertheless, it plays a key role in ice dynamics, mixing with seawater to form a thin, stable, low salinity-density layer, a few to 50 m thick. River inflow influences the export of water and ice, fall freezing and spring-summer thawing, and the upward heat flux from deep Atlantic water during winter [*Antonov*, 1963, 1968, 1976]. More critically, late spring floods on the Ob and Yenisey, through their thermal, hydraulic, and albedo-reducing effects, are the major factor in ice breakup and melt in the Ob and Yenisey gulfs and contribute to it in adjacent zones of the Kara Sea [*Ivanov and Nikiforov*, 1976; *Ivanov and Kurzhunov*, 1980]. First- and second-stage diversions could reduce thermal input to the Ob Gulf 15% and 30%, respectively [*Ivanov*, 1980]. This would significantly delay ice melt and breakup in the southern part of this 51,800 km² estuary. In turn, the ice cover in the northern part of the gulf and adjacent portions of the Kara Sea could be indirectly modified. Soviet researchers at the Arctic and Antarctic Institute in Leningrad have warned that average annual diversions of as little as 20 to 50 km³ annually from the Ob could cause an increase in the sea's ice cover of 2% for each 1% flow reduction [*Ivanov and Nikiforov*, 1976]. Thus a 50-km³ (3.7%) diminution could result in a 7%–8% increase in average summer ice extent. Larger diversions, they believe, could cause a higher multiplier ratio between incremental freshwater inflow reduction and ice cover expansion.

In light of the above (and since the changes induced by a freshwater inflow reduction may lead to instability in the ocean-ice system), careful research and evaluation would be prudent before proceeding with stages of Siberian diversions beyond 60 km³. The magnitude of direct changes from larger transfers (Table 4) are cause enough for concern. Additionally, it should be noted that other human actions in the basins of the Ob and Yenisey, such as existing and planned irrigation and reservoirs, could also affect Kara Sea ice conditions. For example, construction of a chain of huge hydroelectric stations on the Yenisey since the late 1950's has already substantially altered its natural hydrologic regime. The net effect has been a reduction of spring-summer and increase of fall-winter discharge. *Antonov* [1972] convincingly argues this shift should lead to thicker winter ice and later ice breakup in the Yenisey Gulf and contiguous areas of the Kara Sea.

Conclusions

Proposed Soviet river diversion projects have the potential to alter the Arctic ice cover and thereby influence Northern Hemisphere climate. The most intensive impacts would be felt on the ice cover of the Kara Sea. A conceptual systems model shows the ocean-sea ice system that would be affected by diversions to be very complex. Qualitative analysis indicates the overall effects of river diversions would likely be to promote system instability and increase the ice cover. This conclusion requires more research and quantitative verification.

First- and second-stage water transfers from the Ob and Yenisey rivers (up to 60 km³) probably would cause insignificant changes in the Kara Sea ice and certainly imperceptible alterations in Arctic ice as a whole. However, with such a complex system, caution must be exercised in generalizing from small direct impacts to overall consequences because of possible multiplier, synergistic, threshold, and nonlinear transfer functions, which can magnify indirect effects. Thus careful analysis of impacts of water transfers beyond 60 km³ is imperative well prior to implementation.

We cannot accurately predict the effects of river diversions on the Kara Sea ice cover nor what level of flow reductions would cause these impacts to become perceptible. Analyses of one, or even several, impact pathways or feedback loops isolated from the general operation of the system cannot provide reliable answers. The approach of this study provides valuable insight, but it requires sophistication and quantification. Definitive resolution awaits formulation of a coupled numerical model (three-dimensional, time and space variant, physics-based) of the ocean-ice-atmosphere system that is capable of realistically simulating the effects of discrete levels of freshwater inflow reduction over periods of at least several decades. Such a model is beyond current environmental modeling capabilities, if not computer technology. The problem is of sufficient importance that efforts along these lines should be initiated, even if there is no short-term payoff.

TABLE 1. Estimated Mean Annual Water and Salt Budget for the Kara Sea

Balance Element	Volume Transport: km³	% individual budgets	% aggregate budget	Mean salinity, ‰	Salt Transport: 10^9 tons	%
Freshwater gain	1681	100	3.5	—	—	—
Continental runoff	1350	80	(2.8)	—	—	—
Ob and Yenisey rivers	1133[a]	(67)	—	—	—	—
Other rivers and glaciers	217	(13)	—	—	—	—
Precipitation	269	16	(0.6)	—	—	—
Summer import of pack ice	63(70)[b]	4	(0.1)	1.6	0.1	negligible
Freshwater loss	380	100	0.8	—	—	
Export of fall and winter ice	216(240)[b]	57	(0.5)	5.9	1.4	negligible
Evaporation	164	43	(0.3)	—	—	
Saltwater gain	46000	100	96	34.2	1605.6	99.9
Deep Atlantic water[c]	19534	42	(41)	35.0	683.7	(42.5)
Surface Arctic water[d]	4384[e]	9	(9)	32.0	140.2	(8.7)
Barents Sea water[f]	22082	48	(46)	35.4	781.7	(48.7)
Saltwater loss[g]	47302	100	99.2	33.3	1604.3	99.9
Net freshwater gain	1302	—	—	—	—	—
Net saltwater loss	1302	—	—	—	—	—
Total water gain	47682	—	100.0	—	—	—
Total water loss	47682	—	100.0	—	—	—
Salt gain	—	—	—	—	1605.7	100
Salt loss	—	—	—	—	1605.7	100

Calculated from data in *Ivanov* [1976 *a, b*]; *Shpaykher* [1976]; *Aagaard and Greisman* [1975]; *Timofeyev* [1961]; and *Shpaykher et al.* [1972].
[a]Includes runoff to Ob and Yenisey gulfs.
[b]Ice volume.
[c]Entering through St. Anna and Voronin trenches.
[d]Entering between Novaya Zemlya and Severnaya Zemlya.
[e]Residual from salt water balance.
[f]Entering between Franz Joseph Land and Novaya Zemlya and through Karskaya Vorota Strait.
[g]Surface and subsurface outflow.

TABLE 2. Estimated Mean Annual Ice Balance of the Kara Sea

Balance Element	Volume, km³	%
Gain	1170	100
Winter ice formation	1100	94
Summer import of pack ice[a]	70	6
Loss	1170	100
Export of fall and winter ice[b]	240	21
Summer ice melt	930	79
Ice volume, end of summer	420	—
Ice-free area, end of summer, 10^3 km²	416	47[c]
Ice covered area, end of summer, 10^3 km²	469	53[c]
Mean ice thickness, end of summer, m	0.90	—
Ice volume, end of winter	1280	—
Mean ice thickness, end of winter, m	1.45[d]	—
Mean thickness of winter ice formation, m	1.24	—

Calculated from data in *Shpaykher* [1976]; *Shpaykher and Fedorova* [1977].
[a]Chiefly from European Basin.
[b]Chiefly to European Basin.
[c]Percentage of Kara Sea area (885,000 km²).
[d]Actual mean ice thickness is somewhat greater since leads and polynyas cover a small percentage of the sea surface.

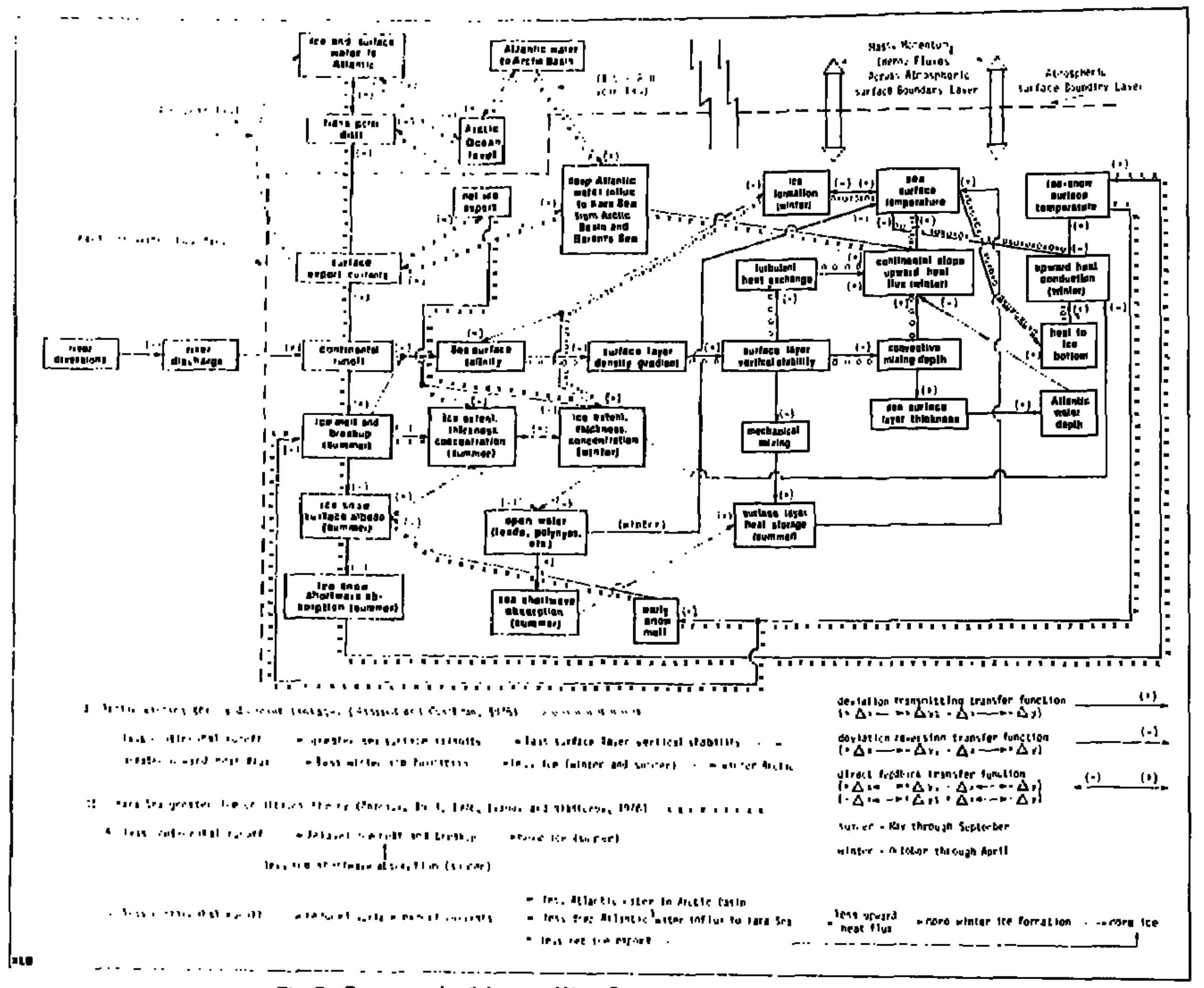

Fig. 5. Ocean-sea ice linkages of Kara Sea system affected by river diversions.

Soviet researchers at the Arctic and Antarctic Institute have developed a two-dimensional hydrodynamic model capable of simulating temporal and spatial variations of liquid, heat, and free ions at the hydrodynamic boundary between seawater and river water [*Molchanov*, 1976]. They believe this model can be used to quantitatively evaluate the effects of different diversion levels on the hydrologic regime of the Arctic seas.

The environmental data base also needs strengthening. Measurements of mass, heat, and momentum conditions and exchanges within and above the Kara Sea, particularly for winter, are woefully inadequate. Severe winter conditions are a serious obstacle to field observations, but data from Soviet and U.S. meteorological and resource evaluation satellites, particularly the upcoming generations with more sophisticated sensors, may be of great help in resolving this problem [*Berestovskiy*, 1978; *Kondratyev*, 1979]. Soviet researchers are currently engaged in a major project to improve the data base for the Kara Sea as part of the FGGE (First Global GARP* Experiment) [*Treshnikov et al.*, 1978].

In view of modeling and data constraints, less sophisticated approaches to systems analysis than a thorough numerical model have considerable merit for the near term. Among these, statistical techniques, such as multiple regression, principle components, and time series procedures, can serve to delineate variables, relationships, patterns, and periodicities of importance in understanding the impact of diversions on the Kara Sea ice cover. The methodology used in this study could also be extended and improved through application of network analysis via graph theory to gain a better understanding of the dynamics of the interactive system that involves river diversions and the ice cover of the Kara Sea [*Roberts*, 1976].

TABLE 3. Preliminary Mean Annual Estimate of the Surface Layer Heat Balance of the Kara Sea

Balance Element	Volume, km³	Heat Flux		
		10^{12}kcal	%	kcal/cm²
Gain	—	149041	100	16.8ᵃ
Deep Atlantic water upward flux (winter)	9461	24811ᵇ	17	15.5ᶜ
St Anna Trench	—	20698	(14)	17.1ᵈ
Voronin Trench	—	4113	(3)	10.5ᵉ
Continental inflow	1350	7000ᶠ	5	—
Ice formation (winter)	1100	70400ᵍ	47	8.0ᵃ
Absorbed solar radiation (summer)	—	46830ʰ	31	11.3ⁱ
Loss	—	149041	100	16.8ᵃ
Winter fluxes to atmosphere	—	57200	38	6.5ᵃ
Ice melt (summer)	930	66960ʲ	45	7.6ᵃ
Other heat losses[k]	—	24881	17	—

Calculated from data in *Timofeyev* [1961, 1962]; *Shpaykher* [1976]; and *Shpaykher and Fedorova* [1977].
[a]Over 885,000 km².
[b]Based on temperature and current data for 1955, which had an anomalously large upward heat flux.
[c]Over 160,191 km².
[d]Over 121,176 km².
[e]Over 39,015 km².
[f]Ob and Yenisey only; mainly expended on spring-summer ice melt.
[g]Heat of fusion assumed at 64 × 10^{12} kcal/km³ owing to brine inclusions.
[h]Absorption by open water areas for July and August.
[i]Over 416,000 km².
[j]Heat of fusion assumed at 72 · 10^{12} kcal/km³; heat for ice melt supplied by river flow, surface layer of the sea, and absorbtion of radiation by the ice cover.
[k]Summer fluxes to the atmosphere, heat exported to the Arctic Basin by surface outflow, and exchange with deeper water.

TABLE 4. Estimated Direct Mean Annual Changes in Selected Characteristics of the Freshwater, Heat, Ice, and Salinity Balances of the Kara Sea From Siberian River Diversions

Balance Characteristic	Natural Conditions	Stage I, 25 km³/yr	Stage II, 60 km³/yr	Stage III, 100 km³/yr	Further Stages, to 220 km³/yr
Freshwater gain, km³	1682	1657	1622	1582	1462
% reduction	—	1.5	3.6	5.9	13.1
Continental runoff	1350	1325	1290	1250	1130
% reduction	—	1.9	4.4	7.4	16.3
Ob-Yenisey discharge	1133	1108	1073	1033	913
% reduction	—	2.2	5.3	8.8	19.4
Ob-Yenisey spring floods, V-VII	657	649ᵃ	638ᵃ	599ᵇ	536ᵇ
% reduction	—	1.2	2.9	8.9	18.4
Heat gain, 10^{12} kcal	149041	148405ᵃ	147769ᵃ	146921ᵇ	145273ᵇ
% reduction	—	0.4	0.8	1.4	2.5
Ob-Yenisey input	7000	6364ᵃ	5728ᵃ	4880ᵇ	3232ᵇ
% reduction	—	9.1	18.2	30.3	53.9
Summer ice melt, km³	930	921	912	901	878
% reduction	—	0.9	1.9	3.2	5.6
Owing to heat from Ob-Yenisey discharge[c]	97	88	79	68	45
% reduction	—	9.3	18.6	29.9	53.6
July-August surface layer average salinity, ‰[d]	30	30.03	30.07	30.11	30.25
% increase	—	0.1	0.2	0.4	0.8
For area of strongest influence of continental runoff[e]	15	15.07ᵃ	15.18ᵃ	15.50ᵇ	16.08ᵇ
% increase	—	0.4	1.2	3.3	7.2

Calculated from data in Tables 1, 2, 3; *Bulatov and Zakharov* [1976]; *Shpaykher et al.* [1972]; *Institut Geografii* [1970]; *Pilikin* [1976]; *Unesco* [1969]; *Gosudarstvennyy Gidrologicheskiy Institut* [1977]; *Vasilyev* [1976]; *Zenkevich* [1963]; and *Ivanov* [1980].
[a]Based on planned annual diversion regime.
[b]Based on estimated annual diversion regime.
[c]Heat of fusion assumed at 72 × 10^{12} kcal/km³; all heat in river flow assumed expended on ice melt; ignores indirect effects on ice melt through albedo reduction.
[d]Period of summer heat storage; average values for entire sea (885,000 km²); calculations assume 2-year river flow retention, 30-m average surface layer thickness, and 0.1‰ river salinity.
[e]Period of average heat storage; average values for area between hydrodynamic front in Ob and Yenisey gulfs and 20‰ surface isohaline (190,000 km²); calculations assume 4-month river flow retention, 10-m average surface layer thickness, and 0.1‰ river salinity.

Appendix

A key issue in evaluating the effects of reductions in river discharge on the ice cover of the Kara Sea is the influence that freshwater inflow has on the sea's hydrology. Comprehensive, detailed oceanographic survey data necessary to determine this are difficult to acquire. After completion of this article, the author learned that in 1965 and 1967 two surveys had been conducted in the Kara Sea by U.S. icebreakers [*Aagaard and Hanzlick*, 1980; personal communications with K. Hughes and V. Zegowitz, National Oceanographic Data Center, November-December 1980]. These data are especially useful because the cruises took place from late July to late September in 1965 and during September in 1967. This is the period when we would expect the maximum effects of the Ob-Yenisey spring floods on the sea.

Two conclusions relevant to the topic of this study are apparent from even a cursory review of these data. First, the effects of river flow on summer hydrologic conditions appear more substantial than indicated in the author's maps and tables. The 1965 survey shows a thin, low-salinity, vertically stable tongue extending far to the north. Nearly 650 km out from the exit of the Ob and Yenisey gulfs into the Kara Sea (78°3'N; 79°44'E), surface salinity is 20‰, whereas at 10 m it is 32‰. This phenomenon is partially due to ice melt, but the influence of river flow is clearly apparent from the high silica content, characteristic of river water, of the surface layer. Second, the rapidity of northward movement of Ob-Yenisey water is surprising. Only 2½ months (late June to mid-September) were required to move the 650 km—an average velocity of 0.1 m/s. This would suggest that the Ob-Yenisey discharge has a significant impact on the northern part of the sea, which is underlain by warm Atlantic water, during the fall. Furthermore, it seems likely that although the average residency time for river water in the entire sea is around 2 years, as calculated by *Aagaard and Hanzlick* [1980], the residency time for the thin surface layer flowing northward from the Ob and Yenisey esturaries is much shorter, perhaps no more than 4–6 months. The combined OB-Yenisey discharge (at the exit into the Kara Sea) in 1965 is estimated at 1098 km³, somewhat below the average of 1133. We could expect, on the average, this flow to be exceeded in 65% of years. Hence, other influences being equal, we could expect the effects of river flow to be greater than in 1965 in the majority of years.

Acknowledgments

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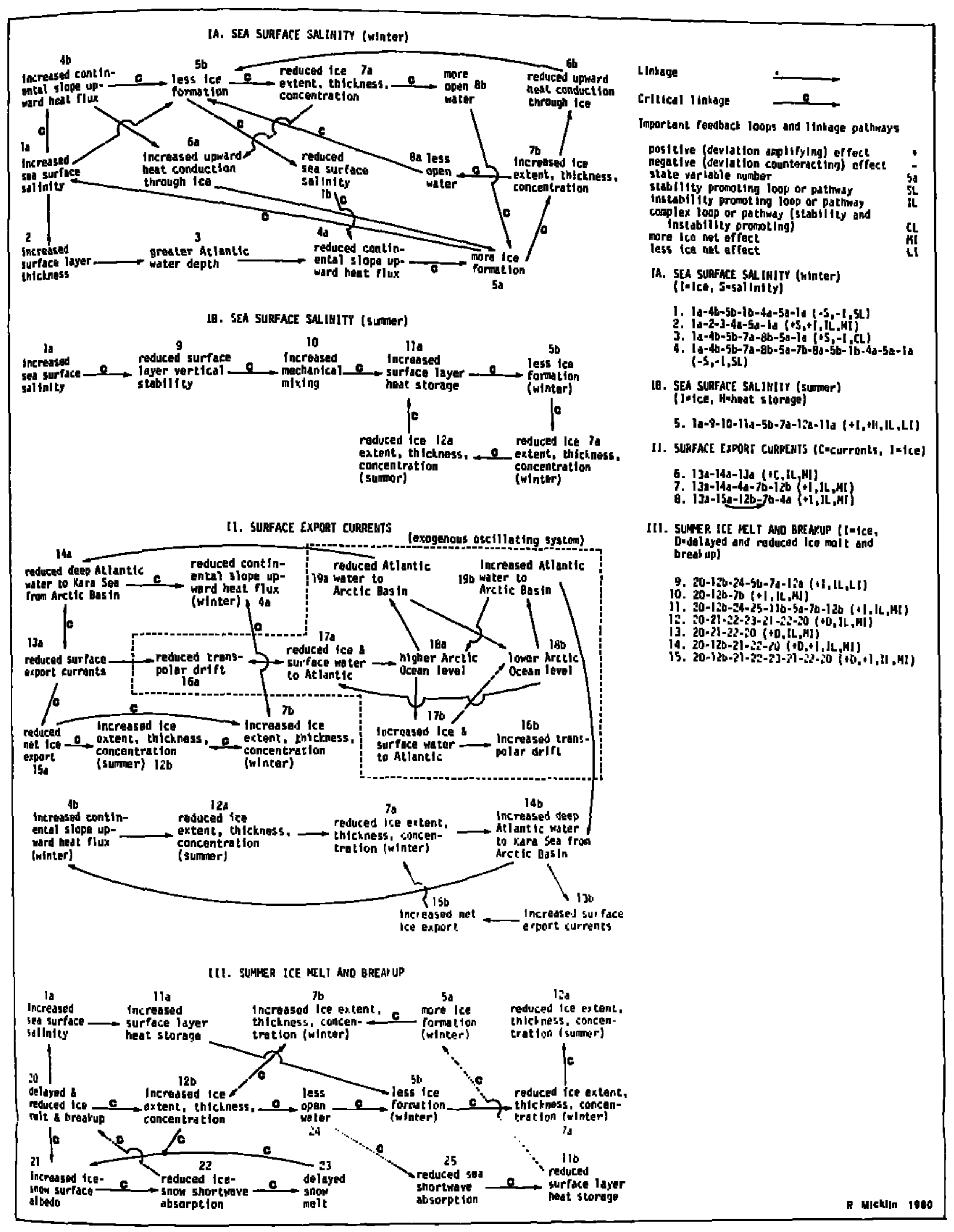

Fig. 6. Critical effect pathways of diversions on Kara Sea ocean-sea ice system.

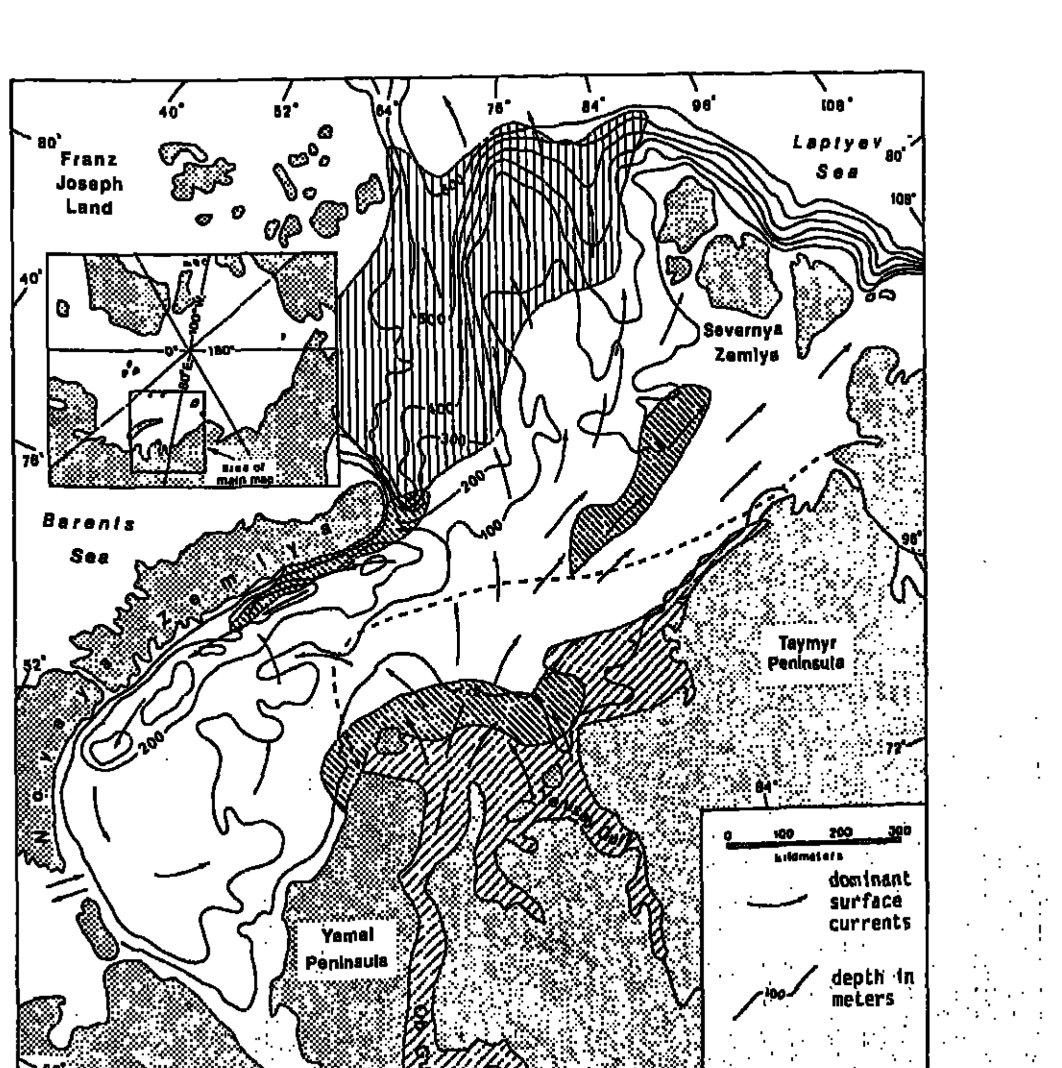

Fig. 7. Kara Sea: critical impact areas. Zones where reduced river discharge might critically alter heat, salt, and ice conditions: verticals—zone of upward heat flux from deep Atlantic water and ice formation and export; right diagonals—zone of river-induced fast ice break up and melt (summer); left diagonals—transition zone (influenced by river flow) between pack and fast ice with thin winter ice and many polynyas and leads (winter); dashed line—limit of zone where surface salinity and heat storage could be significantly altered (summer) (20 ‰ surface isohaline). (Sources: Figures 3 and 4, *Nikolayeva* [1976].)

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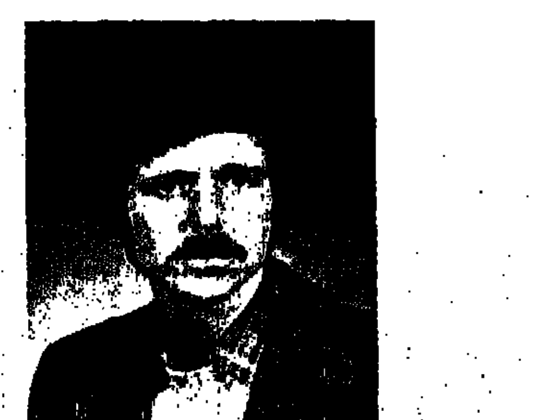

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News

First Space Shuttle Payload

Preparations are being made at the Kennedy Space Center for installation of the first payload to be carried into space aboard the space shuttle *Columbia* during STS-2, its second test flight, now scheduled for this fall.

The payload is called OSTA-1 for NASA's Office of Space and Terrestrial Applications, which is providing most of the seven experiments. It is designed to demonstrate the space shuttle's capability as an operational space platform for scientific and applications research. The experiments are concerned primarily with remote sensing of land resources, atmospheric phenomena and ocean conditions.

The payload experiments include an imaging radar (Shuttle Imaging Radar, or SIR-A) to help test advanced techniques for mapping geological structures important in oil and gas exploration; a multispectral infrared radiometer (SMIRR) to measure the solar reflectance of mineral-bearing rock formations; a feature recognition system (Feature Identification and Location Experiment, or FILE) designed to discriminate between water, bare ground, vegetation, snow, or clouds, and thus control sensors to collect only wanted data; an air pollution measurement experiment (Measurement of Air Pollution from Satellites, or MAPS) designed to measure the distribution of carbon monoxide in the middle and upper troposphere (12–18-km altitude); an ocean color scanner (Ocean Color Experiment, or OCE) to map algae concentrations, which may indicate feeding areas for schools of fish or pinpoint possible pollution problems; a night and day optical survey of lightning storms (NOSL); and a biological engineering experiment (Heflex Bioengineering Test, or HBT) to determine the relationship between plant growth and moisture content in the near weightlessness of space.

An engineering model of a Spacelab pallet, a 3-m-long, U-shaped structure that mounts in the shuttle's cargo bay, will carry most of the experiments. The pallet is equipped with subsystems that provide power, command, data, and thermal interfaces for the instruments.

The imaging radar, radiometer, feature recognition, pollution measurement, and ocean scanner experiments are mounted on the pallet; the lightning and biological engineering experiments are mounted in the shuttle's crew compartment.

STS-2 will be launched from the Kennedy Space Center into a 280-km circular orbit with an inclination of 40.3°. For approximately 3.5 days (88 hours) of the 4-day mission the shuttle will be in an Earth-viewing orientation. In this attitude the shuttle payload bay faces Earth on a line perpendicular to Earth's surface. During this period, the instruments will be operated and data collected. The mission will conclude with a landing at Dryden Flight Research Center, Edwards, Calif.

The flight operations of OSTA-1 will be controlled from the Johnson Space Center. The air pollution and feature recognition experiments operate continuously for the whole mission with the imaging radar, radiometer, and ocean experiments taking data over preselected sites. The lightning experiment is a "target of opportunity" instrument. Experiment housekeeping data is available in the Payload Operation Control Center to monitor the status and health of the instruments, and the payload can be commanded from the control center or by the astronaut crew via the shuttle's general purpose computer.

Since most of the shuttle data transmission capability will be utilized with shuttle status data for the second orbital flight test mission, all the OSTA-1 scientific data will be recorded onboard on tape and film, which will be removed from the shuttle upon landing and turned over to the experimenters for immediate screening and analysis. The instruments will be removed from the *Columbia* after it is ferried to the Kennedy Space Center.

All scientific experiment data will be in the public domain and subsequently made available from the National Space Science Data Center, Goddard Space Flight Center, Greenbelt, Md.—*PMB*

Geophysical Event

Alaid Volcano, northern Kurile Islands, USSR (50.80°N, 155.50°E). All times are local (GMT + 11 hours). A strong eruption from Alaid, located on an uninhabited island in the Kurile group, apparently began during the morning of April 28. Clouds obscured the area until about 0915, when weather satellite imagery revealed a distinct eruption plume that grew steadily for the next 2½ days. Microbarographs at Kushiro Weather Observatory (about 1250 km SW of Alaid) recorded three distinct pressure waves on April 28: at 1143 (0.5 mbar), 1153 (0.2 mbar), and 1340 (0.8 mbar).

Significant ashfalls were reported over a wide area. Tass reported that 20–25 cm of ash fell on the town of Severo-Kurilsk (45 km ESE of the volcano), and residents of Shemya (in the Aleutians, about 1200 km ENE of Alaid) measured nearly 2 mm of ash. Soviet volcanologists overflew the volcano April 29 and observed an ash column that rose to about 10-km altitude from the summit crater. Analysis of weather satellite images returned the next day indicated that the plume consisted of two primary layers, at about 9- to 11-km and 13.5- to 15-km altitude. By April 30 at 1700, the plume was at least 100 km wide, extending east about 700 km to 50°N, 165°E, then bending south and southeast about 1200 km to 40°N, 170°E. Vigorous feeding of the plume from the volcano was continuing.

A preliminary search for strong seismicity associated with the eruption yielded only a single shallow magnitude 6.0 event at 44.04°N, 149.93°E (860 km SSW of the volcano), which occurred on May 1 at 0142.

Information provided by the Scientific Event Alert Network of the Smithsonian Institution.

Smithsonian Offers Research Funds

The Smithsonian Foreign Currency Program, a national research grants program, offers opportunities for support of astrophysics and earth sciences research in Burma, Guinea, India, and Pakistan. Grants in the local currencies of these countries are awarded to senior scientists at United States institutions. Collaborative programs involving host country institutions are encouraged.

Deadline for submission of applications for the grants is November 1. For additional information, contact the Foreign Currency Program, Office of Fellowships and Grants, Smithsonian Institution, Washington, D.C. 20560 (telephone: 202/287-3321).

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The period of employment is expected to run from late summer 1981 to February 1983 (with a possibility of extension depending on available funding); both positions require that the applicant be resident at the South Pole or Siple during the Antarctic winter. Successful applicants will undergo periods of training at Utah State University, Lockheed Research Laboratory, and the University of Maryland.

Applicants should submit a resume and request three letters of reference be sent by 15 May 1981 to F. T. Berkey and J. R. Doupnik, Center for Atmospheric and Space Sciences, Utah State University, UMC 34, Logan, Utah 84322, Telephone (801) 750-2982.

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Geophysicist. Applications are invited for a tenure track position in geophysics for the 1981–82 academic year. The Ph.D. in geophysics or a closely related field is required.

We are seeking a candidate capable of teaching undergraduate and graduate courses and supervising graduate research in seismic exploration geophysics. Specific research interests need not be in that area. Applications are encouraged from individuals with industrial experience.

Applicants should submit a resume and three letters of recommendation to Dr. Moid U. Ahmad, Chairman, Department of Geology, Ohio University, Athens, Ohio 45701.

Ohio University is an equal opportunity/affirmative-action employer.

Postdoctoral/Research Associate Positions, The Johns Hopkins University, Applied Physics Laboratory. Positions are available for studies of magnetospheric-ionospheric coupling, hydromagnetic waves, and plasma instabilities in the ionosphere and magnetosphere. The selected candidates will participate in the analysis and interpretation of data from spacecraft and ground-based radars as well as in the development and implementation of new ground-based and spacecraft studies. Positions are for one year and are renewable. Tenure may begin at any time through September 1, 1981. Applications should be addressed to Mr. Steven F. Sayre, Dept. ADI-15, The Johns Hopkins University, Applied Physics Laboratory, Johns Hopkins Road, Laurel, MD 20820.

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EXPERIMENTAL ATMOSPHERIC CHEMIST

To conduct independent research likely to include marine measurements, tropospheric and stratospheric sampling, global chemical cycles and related scientific areas and management of research group. Requires majority of the following: Ph.D. in chemistry, physics, oceanography, atmospheric science or a closely related discipline or equivalent plus extensive experience with laboratory and/or field measurements relevant to atmospheric chemistry; outstanding skill in experimental techniques for gas measurements; recognized publication record; demonstrated skill at supervising experimental scientists in research endeavors and interacting productively with colleagues in theoretical studies. Salary range: $34,446-$56,796. Candidates may apply by submitting a curriculum vitae and list of publications. Qualification at level III or senior scientist will be based on the degree to which the applicant satisfies the requirements. The Ph.D. scientist III level will be a five year term appointment. For more information or to apply, contact Margareta Domecki, NATIONAL CENTER FOR ATMOSPHERIC RESEARCH, P.O. Box 3000, Boulder, Colorado 80307, (303) 494-5151, ext. 581.

NCAR

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Consejo Nacional de Investigaciones Científicas y Técnicas

CHIEF OCEANOGRAPHER

A postdoctoral scientist with several years experience in physical oceanography is required at IADO (Instituto Argentino de Oceanografía), a joint institution of the Consejo Nacional de Investigaciones Científicas Y Técnicas (National Research Council), the Universidad del Sur, Bahía Blanca, and the Armada Argentina (Argentine Navy).

The applicant, in addition to research and postgraduate teaching in his own field, will also be responsible for the planning, coordination, and supervision of activities in other branches of oceanography at large.

The position is under the auspices of a joint program of the Consejo Nacional de Investigaciones Científicas y Técnicas (CONICET) and the Interamerican Development Bank (IDB). It will be initially of medium duration, and is renewable.

It will be located at Bahía Blanca. Salary and fringe benefits according to qualification. Knowledge of Spanish language will be considered an advantage. For consultations or submitting applications, contact:

Señor Presidente del
Consejo Nacional de Investigaciones
Científicas y Técnicas
Avda. Rivadavia 1917
(1033) Buenos Aires, Argentina.

Applications should include complete academic and professional background along with a list of publications as well as names and addresses of three references.

Research Seismologist. The Alexandria Laboratories of Teledyne Geotech invites applications from Ph.D.-level seismologists to work on problems related to the comprehensive and threshold test ban treaty negotiations. Applicants should have background in such topics as theoretical seismology, seismic data analysis, seismic data gathering, advanced scientific computing, and computer systems. To apply please send your resume to Jean Hill, Pesonnel Department, Teledyne Geotech, 314 Montgomery Street, Alexandria, Virginia 22314.

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Faculty Position Meteorology

Applications are invited for a tenure track or tenured faculty position available 1 September, 1981 in the Division of Meteorology and Physical Oceanography in the Rosenstiel School of Marine and Atmospheric Science of the University of Miami.

The rank and salary will be negotiated depending on qualifications. The applicant must hold a Ph.D. in atmospheric science or a related discipline. The applicant should have atmospheric research and teaching interests that complement the activities of the Division.

Applicants should submit curriculum vitae and the names of three professional references to:

Search Committee
Chairman, R. Bleck
Rosenstiel School of Marine and
Atmospheric Science
University of Miami, 4600
Rickenbacker Causeway
Miami, Florida 33149.

The University of Miami is a private international university and is an equal opportunity/affirmative action employer.

University of Leeds/Isotope Geochemist. Applications are invited for a temporary appointment for a fixed term of up to two years as postdoctoral research fellow in the Department of Earth Sciences, from a date to be arranged, to work on a project in isotope geochemistry and geochronology, funded by the Natural Environment Research Council, UK.

Preferred special interests and experience are expected in radiogenic isotope geochemistry applied to petrogenetic studies and/or mantle evolution. Current isotopic research includes investigations into specific intra-plate and island-arc volcanic provinces, mantle nodules, Precambrian geochronology, thermal evolution of metamorphic belts, and sea-water/sediment interactions.

Salary within the range £6070–£10,160 on the IA Scale for Research and Analogous Staff (£6070–£10,575) according to age, qualifications and experience.

Informal enquiries may be made to Professor J C Briden. Further particulars and application forms (if desired) may be obtained from the Registrar, The University, Leeds LS2 9JT, U.K., quoting reference number 49/16/HG. Closing date for applications 31 May 1981.

Seismology, Sedimentology and Tectonics/Geochronology. The Geosciences Program of The University of Texas at Dallas invites applications for three anticipated tenure track openings in the general areas of seismology, clastic sedimentology and tectonics/geochronology beginning academic year 1981–82. At least one of these positions will be filled at the senior level with rank and salary commensurate with qualifications.

The positions require a Ph.D. and a strong commitment to excellence in research and teaching. Teaching duties will involve both graduate and undergraduate courses, some participation in field courses and supervision of M.S. and Ph.D. students. Candidates with the following research interests are preferred:

Seismology—expertise in solid earth seismology with an interest in applying theoretical modeling or signal processing techniques to earthquake or other seismic problems. Academic Search No. 236

Clastic sedimentology—expertise in depositional systems and/or diagenesis. Academic Search No. 237

Tectonics/geochronology—Expertise in regional geology/tectonics with an interest in isotope geochemistry, geochronology, and petrology. Academic Search No. 238.

Applicants should send a letter outlining specific research interest, a resume (indication of sex and ethnicity for statistical purposes is requested but not required) and names of three references, with the appropriate Academic Search Number, to:

Academic Search No. ___
The University of Texas at Dallas
P.O. Box 688
Richardson, Texas 75080

Applications should be received by July 31, 1981.

The University of Texas at Dallas is an affirmative action/equal opportunity employer.

Dean, College of Geosciences. The University of Oklahoma is seeking a dean for its newly formed College of Geosciences, a college which is comprised of three existing academic departments: Geology and Geophysics, Meteorology, and Geography. In 1981–82 the total faculty will reach approximately forty full-time persons. Presently the student majors represent about 500 undergraduate and 220 graduate students. The College is expected to grow both in faculty and student body over the next several years. There is a firm institutional commitment to the continued development of academic quality in undergraduate and graduate education and research in the earth sciences, already an area of traditional strength at the University of Oklahoma.

Candidates for the deanship should possess a doctorate in an earth science discipline, and should have significant experience in an administrative or academic role involving instructional and/or research activities relevant to the earth sciences. While an understanding of and appreciation for all of the earth sciences is essential, because of the unique traditions of the University of Oklahoma and its relationship to the state and region, there will be a significant focus on energy activities and research.

Among the dean's responsibilities will be: (1) to provide leadership, internally and externally, in energy matters and, particularly, in working with the petroleum and gas industry throughout the Southwest; (2) to assist in the planning and development of a $30 million Energy Center which will house the College of Geosciences and other energy-related disciplines and services; and (3) to provide administrative leadership for instruction and research in such areas as atmosphere, weather and climatology; physical, economic and cultural geography; and the basic areas of geology, geophysics, and geochemistry.

The dean should be able to assume this position in September, 1981, or as soon as possible thereafter, no later than January, 1982. Closing date for applications is June 1, 1981. Please send nominations, applications, and arrange for at least three letters of reference.

EO/AAE. Apply: Professor Neil E. Salisbury, Chair, Geoscience Dean Search Committee, Department of Geography, University of Oklahoma, Norman, Oklahoma 73019

Atmospheric Scientist/Radiation Physicist. Current Applied Research and Systems activities have created immediate openings in the following areas

1. Spectroscopy, Radiative Transfer and Atmospheric Sciences (1 Position). Requires to work on the general circulation modeling of stratosphere
2. Atmospheric Fluid Dynamics (1 Position). Requires to develop global atmospheric dynamics problem in the thermosphere

These positions are in support of science and application tasks of NASA Goddard Space Flight Center, Greenbelt, Maryland and require one to work onsite.

An extensive background in the numerical simulation of physical problems by use of mini and large computers is required. Candidates must have M.S. or Ph.D. in atmospheric sciences or physical sciences. Both of these positions are renewable up to two years.

Salary range is $21,000 to $35,000 per annum, depending on qualifications. Good Benefits. Qualified applicants should send three references, salary history and requirements to

Dr S P S Anand
Applied Research and Systems
8401 Corporate Drive
Suite 650
Landover, MD 20785
Telephone (301) 459-8442

Louisiana State University. The Department of Geology anticipates one or more temporary positions at the assistant professor or higher level will be available in the fall or spring semesters 1981–82. Applications in any field of geology or geophysics will be considered. The Ph.D. is required. There is a possibility of the positions becoming tenure track. Applicants should submit a vita, reprints, a statement of teaching and research interests, and arrange for three letters of recommendation to be sent to Dr. R. H. Pilger, Jr., Chairman, Search Committee, Dept. of Geology, LSU, Baton Rouge, LA 70803. Application Deadline July 15, 1981.

LSU is an equal opportunity affirmative action employer.

Physical Oceanography. A research and teaching position for a visiting scientist is available for the 1981–82 academic year. The position is state supported with a salary range of $19,000 to $26,000 for nine months at a rank from assistant to full professor, depending on the applicant's previous experience. Applicants should have demonstrated experimental research ability in current dynamics, waves, turbulence or ocean remote sensing, and should be willing to teach at least one course. Interest in interacting with existing research programs in turbulence, optical oceanography, or coastal processes is encouraged.

Send curriculum vitae, the names and phone numbers of three references to: Chairman, Department of Marine Science, University of South Florida, 830 First Street South, St. Petersburg, Florida, 33701. Application will be accepted through June 30, 1981.

Meteorite Research at UCLA. Applications are invited for a postdoctoral position, salary about $19,000 per year. The job duties involve experimental and theoretical studies relating to the origin of meteorites. Requirements for the position are a science Ph.D. and a minimum of 2 years meteorite research experience. Send resumé to J. T. Wasson, Institute of Geophysics and Planetary Physics, University of California, Los Angeles 90024

UCLA is an affirmative action equal opportunity employer

STUDENT OPPORTUNITIES

Graduate Students Research Assistantships, St. Louis University, Paleomagnetic Laboratory. Two positions are open for paleomagnetic research work conducted under NSF sponsorship. The positions are for one year and are renewable. The candidates are expected to apply simultaneously for admission to graduate school to pursue studies leading to a MS and or Ph D degree in geophysics. For more information, contact Dr. S. A. Vincenz, Department of Earth & Atmos. Sciences, St. Louis University, P.O. Box 8099-Laclede Sta., St. Louis, MO 63156, Telephone (314) 658-3128 and simultaneously, Dean of Graduate School, St. Louis University, 221 N. Grand Blvd., St. Louis, MO 63103.

SERVICES

Scripps Remote Sensing Tutorials.

1A *Overview of the Remote Sensing Facility*—This one-day seminar describes the data bases sources and processing capabilities available at Scripps Institution of Oceanography Remote Sensing Facility. A morning lecture will introduce past current and future space platforms available for observation of the Oceans. A brief discussion of where and how to access this information will conclude the first part of the class.

The afternoon will include a demonstration of processing and displaying imagery obtained from TIROS-N, NOAA-6 and NIMBUS-7.

Classes will be held at the Helen Raitt Room SIO Library on Monday, April 20, 1981 and Monday, July 27, 1981, at 8:30 am. A nonrefundable fee of $50.00 must be submitted with the application. Enrollment limit—12

2A *Users Introduction to the Scripps Remote Sensing Facility*—This four-day workshop is intended exclusively for individuals who will be using the facility at Scripps. Two morning lectures will describe in detail the hardware, software and personnel resources available to oceanographers. Existing data bases, their characteristics, location, mode and cost of access will be covered. Basics of image processing will be introduced along with in-depth look at the Interactive Digital Image Manipulation System used at the SRSF.

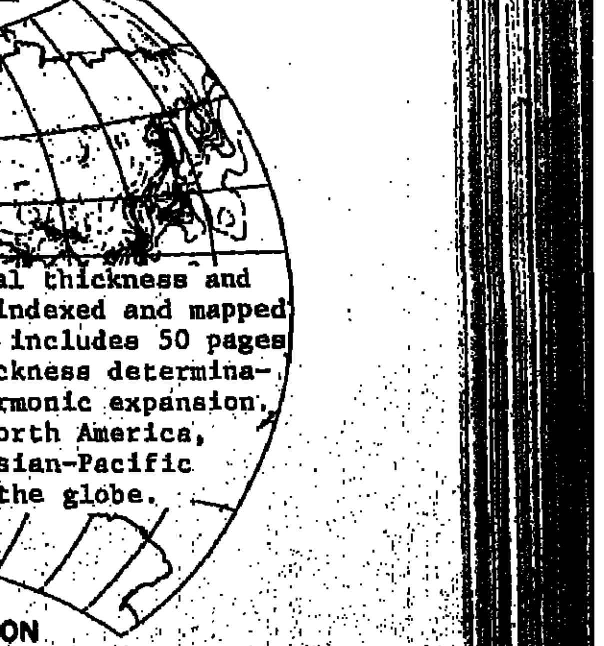
The two lectures will be followed by afternoon lab sessions which consist of hands-on exercises to familiarize users with the hardware software at the facility. The third morning will be devoted to train users in realtime spacecraft tracking and data recording and acquisition.

The remainder of the 3rd day and the entire 4th day will be used to work with users on a one-to-one basis. Attendees are encouraged to bring their own digital tapes with data of interest to them, which can be used during this last portion of the workshop.

Classes will be held in the Helen Raitt Room SIO Library starting on Tuesday, April 21, 1981 and Tuesday, July 27, 1981 at 8:30 am. A fee of $335.00 must be submitted with each application. Enrollment limit—6.

For more information regarding applications, fees, etc., please contact University of California at San Diego, SRSF/SIO, Mail Code A-030, La Jolla, California 92093 or (714) 452-2292.

CRUSTAL THICKNESS DATA BASE



An up-to-date compilation of crustal thickness and Pn velocity data from 249 sources, indexed and mapped in three colors. Soft-bound report includes 50 pages of bibliography, list of 2131 thickness determinations, 9 maps, and a spherical harmonic expansion. Data contours are mapped for North America, Europe, Tibetan plateau, Eurasian-Pacific plate juncture (Japan) and the globe. price $15.00

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